An Example of Influence on Reduction of Electrical Energy Costs

Dragan R.Milivojević[1], Viša Tasić[2], Vladimir Despotović[3], Aleksandra Ignjatović[4]

Abstract **–This paper shortly describes realized computer network used for monitoring of electrical power consumption in consuming transformer station at the copper mine and copper smelting plants in Bor and Majdanpek. Some effects on reduction of costs by control of peak power were specially noted.**

Keyword – **electrical power consumption, process control, peak power, monitoring system**

I. INTRODUCTION

Copper Mining and Smelting Complex Bor (RTB) is certainly among greatest electrical energy consumers in Serbia and Montenegro. About 80 thousands MWh of active electrical energy are consumed monthly in its production sites (mines, flotation plants, smelters and refineries and copper treatment in Bor and Majdanpek), what is about 1 000 000 US$, if the costs of maximum power (peak) are considered.

Certainly, it is not required to state the other reasons for permanent or periodical measures for reduction of mentioned costs.

Beside often normative and organizational actions, the decision was made to begin with the realization of a real time based monitoring system for control of electroenergetic system in RTB Bor. The known performers from the production sites of RTB Bor and Copper Institute were engaged in this work. Strong connection and cooperation of two basic groups of experts: technologists (energetic and process engineers) and automatic engineers (primary, experts for informatics) was required for successful realization of this complex project.

The pilot operation of the system has started from the middle 1990's in Bor's part of Complex, and later an identical system has also been developed at the Copper Mine Majdanpek (RBM).

II. CHARACTERISTICS OF A CONTROL SYSTEM

Due to a great complexity of electroenergetic network in RTB, a large number of transformer stations and their spatial dislocation, the first project stage had to include only the consuming transformer stations.

[1] Dragan R. Milivojević is with the Copper Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia and Montenegro, e-mail: dane@ibb-rtb.bor.co.yu
[2] Visa Tasić is with the Copper Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia and Montenegro, e-mail: visa@ibb-rtb.bor.co.yu,
[3] Vladimir Despotović is with the Copper Institute Bor, Zeleni bulevar 35, 19210 Bor, Serbia and Montenegro, e-mail: vlajcheck@ptt.yu,
[4] Aleksandra Ignjatović is with the EMS Beograd, Serbia and Montenegro, e-mail: a.ignjatovic@ems.co.yu

The preparation of transformer stations was carried out in such way that the measuring power converters, connected as it is shown in Fig. 1. were installed into the measuring circuit of secondary cells of all transformers (supply and for the all subdivide ones). Outputs from the measuring power converters are standard current signals (4 - 20 mA) proportional to the active and reactive power of given transformer cell. Transmitters (measuring converters) of active and reactive power, are the result of our own development, and their basic characteristics are: Aron's measuring methods, input voltage is 3x100 V symmetrically, output is 4 - 20 mA, unlinearity < 1% and overloading up to 20%.

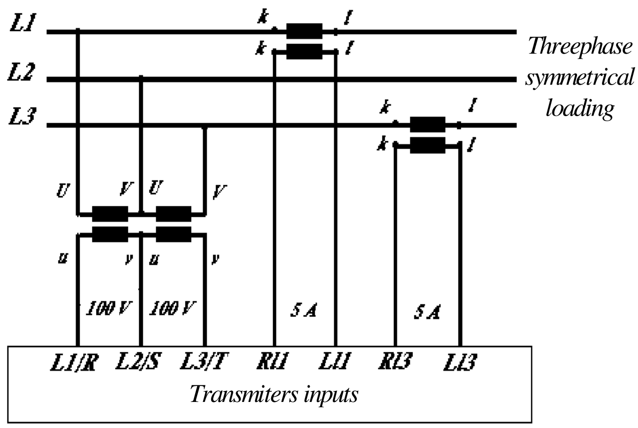

Fig. 1. Way of connection the P&Q transmitters

Signals from the P&Q transmitters are supplied to the inputs of universal measuring station (UMS), which carries out measuring (sampling). Measuring method includes A/D conversion of inputs and processing of the obtained numerical values. It was experimentally estimated that measuring at 200 ms gives a real view on changes of involved power. More frequent sampling does not give noticeable better results due to the system inertia. 8-bit A/D conversion is used and it is expected that conversion error is less than 1 LSB, i.e. lower than 0.5%.

Data processing starts with logic control. Possible saturation at inlet is checked disregarding a fact that it is a result of measuring converter error, or bad signal condition at inlet into measuring station. Negative value of active power also causes the error message. Since the measuring is carried out five times per second, then the average value of power represents the minute power. Every minute it is transferred to the PC workstation (at the control center). Since the 15-minute average power is calculated for the electrical power rate and payment, measuring stations calculate this power as a cumulative divided by the number of minutes in a range of given 15 minutes (depending on number of messages received). Such measuring method gives a possibility for prediction of overload of given (or maximum) power limit for any plant and each transformer in the transformer station. It is worth mentioning that the measuring station checks all conditions (switches and ground protection) at every 100 ms. The condition signalization is not done in some transformer stations, so this possibility is not useful, but in principle it is possible to have the information on condition change with time resolution of 1/10 seconds.

III. Operation method

All consumer transformer stations (two in Bor and three in Majdanpek) are measured. Regarding to their dislocation and distance from control center, it was necessary to realize the computer network that includes the measuring devices in transformer stations and personal computer in control centre. Fig.2. presents the hardware network structure in the Copper Mine Majdanpek (RBM).

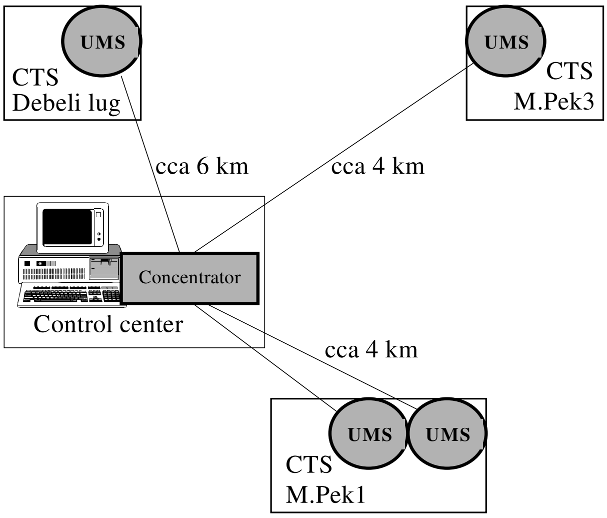

Fig. 2. Disposition of consumer TS (CTS) and UMS in RBM

Hierarchic type of computer network is a starlike structure with central control [5]. The main unit in network is the concentrator [1], and secondary nodes are PC and measuring stations. Transmission lines are leased telephone lines, and the base band modems are used for the synchronous transmission. The operation of all devices and network functions are carried out under the control of suitable software.

Executive versions of program modules are included at the measuring station's EPROM: test-control, operational and communication program module. The complex communication program enables concentrator to configure and maintain network in the operational regime.

PC (expanded with hardware communication module) in control center carries out the application program for real time monitoring of the electroenergetic system. This program [2-4], includes three basic modules: communication module for data receiving from measuring stations, operational module for real time data processing and their presentation on the screen, and module for offline data processing and archiving. Interaction with the process is obtained under control of operational program, and it is reflected in forced warning messages on a screen. Those messages inform on limit or maximum power overload (peak) at each transformer station, or some technological or organizational part of the company, regarding to a possibility of prediction of the involved power in a range of 15 minutes. As a reaction on warning message, some consumers could be switched off or switched on, if it is technically possible and economically justified.

After a period of pilot operation, realized system has turned into exploitation stage. It has shown out the satisfied stability and acceptable reliability from a technical point of view. Organizational side has not completely followed the technical possibilities of installed system. The resistance was understandable because the "objective" costs limitation would disturb the previous agreeable distribution, where unrational consumption of some plants was overturned to the rest of company complex. Besides all, at the beginning of its operation, the system had positive effects, because the greater consumers, aggregates with power greater than 300 KW were switched on whenever it was possible, with the agreement of control center (they needed some kind of permission).

The positive effects were both technological and psychological. Technological influence is realized in change of work organization and sufficiently rapid monitoring of involved power, with a possibility of influence on its reduction (switching off or blocking of switching on, i.e. warning on exceeding) whenever it is possible. Psychological influence is reflected in increase of technological discipline and responsibility of performer, due to knowledge of presence of objective measuring and supervision.

IV. Results review

It was already mentioned that the involved power and energy are monitored at the plant level. Program solution for analysis and data review for every plant and organizational part was developed. The greatest system contribution in costs optimization is an influence on decrease of maximum power. Since there is sufficient number of data for plant's consumption, it is possible to determine the limit power and give it as a parameter to the system, so that it could warn on approximation to this value, or alarm its exceeding. Program solution allows two levels of power limit and it could be dynamically changed.

The serious team work of technologists and energetic engineers, and experiments from the field of finances are required for realization of universal and qualified analysis of behavior of the electroenergetic system in RTB Bor and Majdanpek. Discussion of those results could not give a real illustration on rational consumption if production is not taken into consideration, i.e. if energetic condition is not calculated (quantity of consumed energy per product unit: tone of cathode copper), and if this data are not compared to equivalent world parameters. Report on monthly consumption and maximum power for consumer transformer station Bor 3 for 2004 and part of 2005 will be used for a superficial analysis of consumption. A part of standard report which also includes a limitation of consumed electric energy (active and reactive) per pay scales and shifts, including the financial indexes (price of active energy, reactive energy and maximum power), for RBM is presented in Table I.

	E_a (MWh)	P_{amax} (kWh)	E_a/P_{max}
2004			
January	26298	39160	0.6715
February	23987	37420	0.6410
March	27300	38620	0.7068
April	20400	36450	0.5596
May	21570	34720	0.6212
June	22620	38120	0.5933
July	31640	32800	0.6597
August	21460	32000	0.6706
September	21520	31230	0.6890
October	22507	38820	0.5797
November	22856	39380	0.6803
December	24965	39950	0.6249
2005			
January	24009	38.23	0.6280
February	21749	39.79	0.5466
March	21387	37.41	0.5717

Table I. Consumed active electric energy in consumer transformer station Bor3 per months in 2004. and 2005. year.

Due to a complexity of energetic network, some plants are supplied simultaneously from many transformer stations (Floating pump station) or they could be alternatively supplied from various sides. It is necessary to treat correctly every energetic configuration in program solution for analyzing of measured data in real time and data processing and preparation. The expert support of main energetic engineer and suitable assistants in the plant is required in this work. Data on time origin of maximum power for the whole region and also for all consumer transformer stations in RTB are reported by the energy supplier in the first half of month for the previous month. Regarding the existence of data on 15 minutes power, a measured results with given time are simply extracted from database, and a report on involved power per transformer stations and plants at the time of regional maximum is made. If it is known that this participation of maximum power (peak) in total costs is important (near 50%), the costs restriction based on this could force the plant's employees to be more careful in a process of greater consumers involvement.

By superficial analysis of Table II, it is noticed that monthly consumption of active energy is nearly the same, and a distribution according to the rate items is completely uniform and maintained.

A part of standard report is given in Fig. 3. as an illustration of participation in maximum power of RTB plants, supplied from consumer transformer station Bor 3 in February 2004.

Month	Rate	E_a (MWh)	E_r (MVAh)	P (MW)
February	High	5122	1153	Min. 7.61
	Low	4999	1032	Max. 20.47
	Total	10121	2185	Aver. 15.06
March	High	5955	1629	Min. 7.80
	Low	5645	1255	Max. 20.11
	Total	11600	2884	Aver. 15.60
April	High	5642	1628	Min. 6.98
	Low	5465	1294	Max. 20.65
	Total	11107	2922	Aver. 15.42
May	High	5057	1610	Min. 1.54
	Low	5029	1501	Max. 21.95
	Total	10086	3111	Aver. 13.56
June	High	5680	1393	Min. 3.68
	Low	5625	1177	Max. 20.99
	Total	11305	2570	Aver. 15.70
July	High	5296	1783	Min. 2.88
	Low	5249	1619	Max. 20.59
	Total	10545	3402	Aver. 14.65

Table II. Part of the report on consumed electric energy and power.

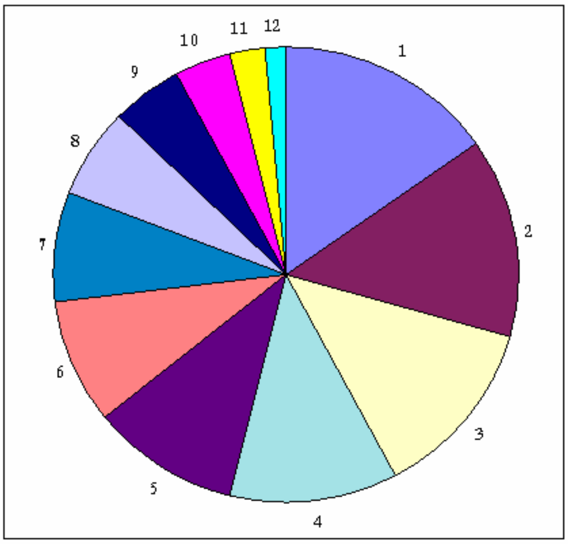

Fig. 3. Distribution of maximum power (peak) Legend: 1. New Flotation Plant (13 %); 2. Old Flotation Plant (9 %); 3. Haulage Shaft (4 %); 4. Contact (8 %); 5. Thermoelectric Power Plant (3 %); 6. Heating Plant (6 %); 7. Oxygen Plant (6 %); 8. Foundry Plant (5 %); 9. Sulphuric Acid Plant (0 %); 10. Electrolytic Refinery (12 %); 11. T100 (11 %); 12. T456 (23 %).

V. CONCLUSION

The process control system of electroenergetic system in RTB has justified its development and financial investments. As far as there is economical force for saving, it is possible to introduce an obligation of cooperation between all parts of plant and control centre in order to obtain more effective power consumption control and monitoring.

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